THE OHIO STATE UNIVERSITY, DEPARTMENT OF ANIMAL SCIENCES

Mitigation of Methane via Nitrate Feed and Yea-Sacc® Supplementation

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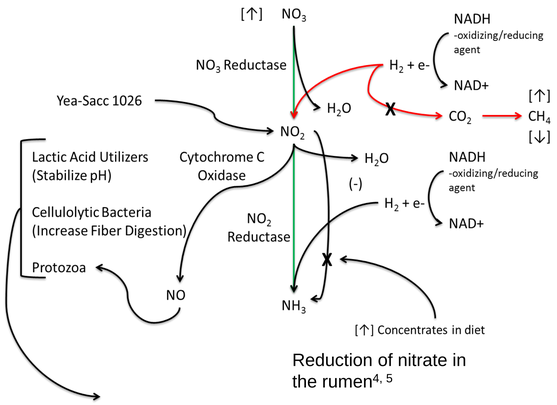
INTRODUCTION

Methane (CH_4) and CO_2 are by-products of the microbial fermentation of carbohydrates in the rumen of dairy cattle. Ruminant livestock produce 17 and 3.3% of CH_4 and greenhouse gases, respectively, from enteric fermentation[1]. High producing dairy cattle are responsible for approximately 128 kg CH_4/head[2]. Thus, decreasing enteric CH_4 could substantially decrease the amount of greenhouse gases produced by the dairy industry. Nitrate was fed for this study because its reduction is thermodynamically more favorable than CO_2 reduction[3]. Yea-Sacc® is a live strain of yeast, *Saccharomyces cerevisiae*.



Reduction of nitrate in the rumen[4, 5]

AIM

The present study aimed to feed nitrate to dairy cows to mitigate ruminal CH_4 production by allowing nitrate reducers to outcompete methanogens for H_2 produced during fermentation. *Selenomonas* species of bacteria are the best characterized nitrate-reducing bacteria in the rumen. Some strains ferment lactate to propionate. On the other hand, either CO_2 or nitrate reduction should help maintain acetate production because it is coupled with H_2 production. *S. ruminantium* activity and H_2 uptake has increased with live-yeast supplementation in published studies, so Yea-Sacc® was added to encourage *S. ruminantium* to reduce nitrate fully to ammonia.

Hypotheses:

- Feeding nitrate would increase ammonia production and decrease CH_4 production but might be unpalatable.
- Because Yea-Sacc® often enhances DMI and stimulates nitrate reducers, the combination of nitrate and Yea-Sacc® would further decrease CH_4 while maintaining milk production.

METHODS

- Study conducted on 12 lactating Jersey cows at Waterman Dairy Farm
- Replicated Latin square design of 4 periods
- Transitional period

Treatments:

- Yea-Sacc - NO_3	+Yea-Sacc - NO_3	- Yea-Sacc + NO_3	+ Yea-Sacc +NO_3
Included at 1.5% of dietary DM:			
Urea	$CaNO_3$	Urea	$CaNO_3$
Topdressing (50 g):			
Control	Yea-sacc mix	Control	Yea-sacc mix
•Total Mixed Ration •Ad libitum water			

Samples collected week 4 of each period:

- Rumen Fluid (0, 3, 6, & 9 h post feeding)
  - N=4
- Methane (before & 3 h post feeding)
  - N=8
- Blood
  - N=12

GreenFeed machine

RESULTS

No effect of time was observed across treatments; data are expressed as treatment means. Total VFA concentration decreased with Yea-Sacc® (main effect). The combination of nitrate and Yea-Sacc® had the highest acetate and the lowest propionate concentrations, resulting in the highest acetate:propionate ratio (interaction; p=0.01; Table 1).

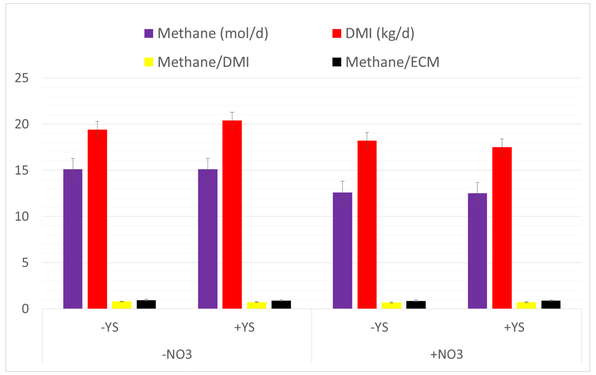
Table 1. Volatile Fatty Acid Concentrations

	-NO_3		+NO_3			P values for contrasts		
	-YS	+YS	-YS	+YS	SEM	NO_3	YS	NO_3*YS
Total VFA, mM	98.3	92.1	94.8	90.8	4.8	NS	0.11	NS
VFA, mol/100 mol								
Acetate	63.6	61.5	61.9	63.7	1.3	NS	NS	< 0.01
Propionate	20.1	22.4	20.1	18.5	1.3	< 0.01	NS	< 0.01
Butyrate	11.6	11.7	14.2	13.9	0.5	< 0.01	NS	NS
Isobutyrate	0.98	1.07	0.84	0.98	0.07	0.11	0.14	NS
Isovalerate	1.44	1.68	1.43	1.58	0.20	NS	0.01	NS
Valerate	1.40	1.53	1.46	1.37	0.13	NS	NS	0.13
BCVFA	3.82	4.28	3.73	3.93	0.25	0.10	0.02	NS
Acetate:propionate	3.11	2.88	3.13	3.47	0.23	<0.01	NS	0.01

YS=Yea-Sacc®, VFA=Volatile Fatty Acids, NO_3=Nitrate, BCVFA=Branched-Chain Volatile Fatty Acids

Figure 1 data expressed as treatment means. CH_4 production (15.1 vs. 12.6 mol/d) and DMI (19.9 vs. 17.8 kg/d) decreased when fed nitrate (main effect; p<0.01). Nitrate tended to reduce methane/DMI (main effect; p=0.14). Yea-Sacc® treatment did not affect CH_4 production or DMI.

Figure 1. Methane Production and Dry Matter Intake (DMI)



ECM=Energy Corrected Milk

No interaction was found with time for ammonia concentrations; Figure 2 means are expressed over time. Ammonia concentration increased (10.3 vs. 12.2 mg/dL of NH_3N) when fed nitrate (main effect; p=0.11), which supported proof of concept. Methemoglobin increased slightly (0.55 vs. 1.53%) when fed nitrate (main effect; p=0.01); being below 30%, this was not a concern.

Figure 2. Ammonia Concentrations and Methemoglobin Percentages

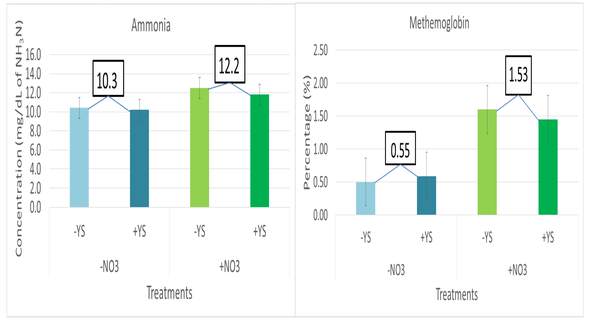
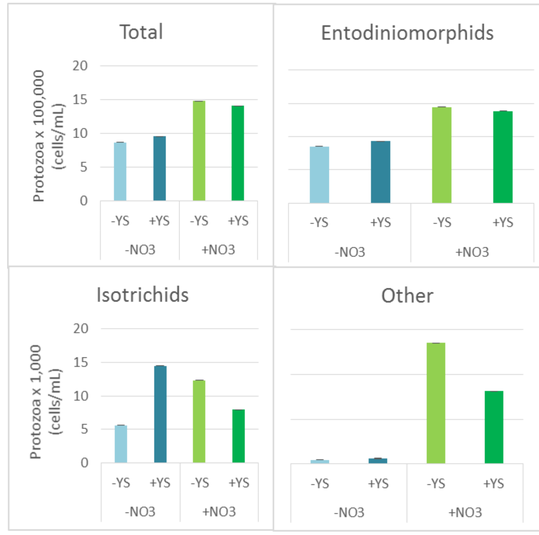


Figure 3 data had no effect over time. Total protozoa numbers increased when fed nitrate (main effect; p=0.02), probably explaining the increased butyrate (main effect; p<0.01; Table 1). Nitrate increased the total, entodiniomorphid, and other protozoa numbers (p<0.03). There was a treatment interaction for isotrichid concentration (p=0.11).

Figure 3. Protozoa Concentrations



CONCLUSION

Nitrate in feed successfully outcompeted methanogens and, in turn, was reduced to ammonia. Nitrate competed with CO_2 for electrons from H_2. Methemoglobin increased but to a percentage that was not a concern. Determination of bacterial DNA results would help explain if *Selenomonas* increased when nitrate and Yea-Sacc® were fed. The topdress, Yea-Sacc®, did not increase DMI, so future research should focus on lower dosages or other nitrate forms to improve palatability. This type of in vivo research has helped explain how the microbiome structure is changed after a major disruption of inter-species hydrogen transfer.

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